Magnetoresistance in the Junction with Multiferroic BiFeO$_3$

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1. Introduction
Multiferroics with magnetic and electric order have attracted much attention because of strong magnetoelectric coupling in these materials. Particularly, BiFeO$_3$ (BFO) is the promising material because of high magnetic and electric transition temperature. Since some reports indicate interfacial ferromagnetism at BiFeO$_3$/ferromagnet interfaces[1], enhancement of magnetoelectric coupling is expected on these junctions. In this work, it was found that the resistance of the La$_{0.6}$Sr$_{0.4}$MnO$_3$ (LSMO)/BFO-junction monotonically decreased under magnetic field in low temperature, which behavior was similar to colossal magnetoresistance (CMR) in perovskite manganites such as LSMO.

2. Experimental Method
SrTiO$_3$ sub./La$_{0.6}$Sr$_{0.4}$MnO$_3$(70)/BiFeO$_3$(20)/Ru(2)/Au(10) (thickness in nm) junction was prepared by r.f. magnetron sputtering. Conventional photolithography and Ar ion milling techniques were used for processing. Electric conductive properties ($R$-$T$, $R$-$H$, and $I$-$V$ curves) were measured using PPMS and pico-ammeter (Keithley 6487).

3. Experimental Results
Fig. 1 shows the $R$-$T$ curves for the LSMO/BFO-junction and the LSMO single-layer. Resistance of LSMO decreased with temperature after magnetic transition at ~320K. On the other hand, resistance of the LSMO/BFO-junction increased with decreasing temperature. Fig. 2 shows the $R$-$H$ curves for the junction at 50K. Junction resistance decreased with increasing magnetic field. The $R$-$H$ property was similar to CMR. However, LSMO was completely ferromagnetic metal in this temperature region in case of the LSMO single-layer. Therefore, this magnetoresistance in low temperature should be observed in the junction system rather than the LSMO single-layer. The interaction between BFO and LSMO might exist in the junction. MR ratio of ~-50% was obtained under ±90 kOe at 50 K.


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Fig. 1 $R$-$T$ curves for the LSMO/BFO-junction and LSMO

Fig. 2 $R$-$H$ curves at 50 K for the LSMO/BFO-junction.